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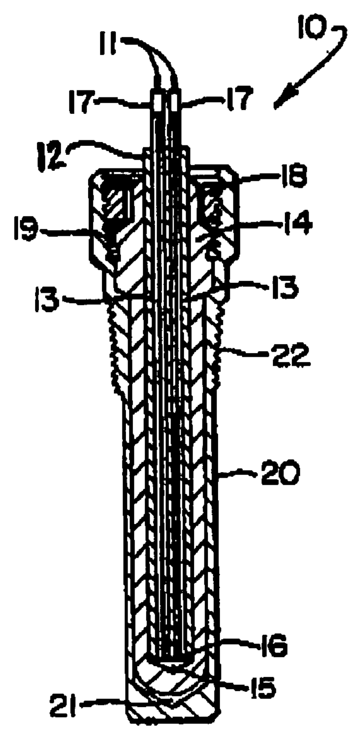
Published
With international search report.
With amended claims and statement.

(54) Title: THERMOCOUPLE EQUIPPED WITH CERAMIC INSULATOR AND SHEATH AND METHOD OF MAKING SAME

(57) Abstract

A thermocouple assembly comprising a unitary, axially elongated ceramic insulator (12) formed with a pair of axially-extending passageways (13) for receiving a pair of thermoelements (11), and an axially elongated unitary ceramic sheath (14) provided with a chamber (15) having a closed end for receiving the elongated, ceramic-insulator (12). This thermocouple assembly (10) may be housed cartridge-style in an existing thermowell, or inserted into a stainless steel tube (20) which is then threaded into the wall of a chamber to be monitored, or provided with a spark plug-type externally threaded shell (23) for mounting in an exhaust manifold or the like. In this manner, a durable and readily replaceable thermocouple assembly (10) is provided.



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\+ It is not yet known for which States of the former Soviet Union any designation of the Soviet Union has effect.

Title: Thermocouple Equipped with Ceramic Insulator and Sheath and Method of Making Same

Background of the Invention:

The present invention relates to temperature sensing apparatus and more particularly to those devices adapted for use with internal combustion engines, nuclear reactors, and other apparatus which require high temperature monitoring.

In the past, various apparatus which operate at high temperatures have been equipped with thermocouples, particularly the "J" and "K" types, which have been inserted to monitor reaction temperatures. The materials which jacketed these temperature sensing elements were typically formed from stainless steel or other conductive metals. Much of the read-out instrumentation to which the thermocouple was attached required electrically ungrounded thermoelements. Accordingly, the metal jackets were electrically isolated from the iron-constantin or chromel-alumel thermoelement wires, typically by filling the space between the elements and jacket with powdered magnesium oxide. The major deficiency of these previous thermocouple designs was the use of a hygroscopic mineral oxide to insulate the metallic thermoelement wires from the

metal, protective jacket. The insulative capacity of the mineral oxide was compromised by water vapor invading the insulative material from the surrounding atmosphere. Even a slight amount of moisture in the powdered mineral oxide permitted formation of at least a temporary ground between the jacket and the thermocouple wires, thereby rendering the device non-functional. Over the years, this problem was tolerated, with many operators simply discontinuing use of the thermocouple and associated pyrometer for a period of time. However, with the growth in use of unmanned machinery, the constant monitoring required for computer control and computer monitoring, and the dangers posed by excessive temperatures in combustion reactions, the need for a durable and reliable thermocouple has become paramount.

For example, use of thermocouples in internal combustion engines, particularly in monitoring exhaust gas temperatures, has become more widespread and critical. In addition to the above-mentioned grounding problem, conventional thermocouples were frequently sized to project deeply into the exhaust gas stream. Naturally, the metallic jackets for such elongated thermocouples were subject to considerable wear from exposure to hot and corrosive gases.

In addition, many earlier thermocouples employed tapered pipe threads for attachment to the exhaust manifolds. Removal and replacement typically involved a cutting torch, thus requiring engine shutdown, so that possibly combustible gases in a classified location (i.g.,

Class 1, Group D, Division 1 or 2) or other engine room were not ignited by sparks from the torch. Likewise, in the absence of a relatively permanent thermowell from which the spent thermocouple could be extracted, engine shutdown was required so that poisonous exhaust gases would not escape through the opening in the exhaust manifold formed when the old thermocouple was removed.

Accordingly, the present inventor was faced with the problems of devising a thermocouple which was substantially impervious to moisture, capable of withstanding substantial heat and vibration, less exposed to the corrosive forces within the high temperature environment, and easily removed and replaced.

Summary and Objects of the Invention:

The thermocouple which is the subject of the present invention basically comprises at least one thermoelement, a unitary ceramic insulator formed with at least one thermoelement-receiving passageway, and a unitary ceramic sheath formed with an insulator-receiving chamber. In addition, the present thermocouple may be equipped with a metal shell formed with a sheath-receiving bore and provided with cooperative fastening means for securing the thermocouple in an operative position. Preferably, the above-mentioned cooperative fastening means includes standard spark plug threads, but may also use NPT threads. It is also preferable for the above-mentioned metal shell or

jacket to be constructed in such a manner that a sensor end of the thermoelement extends into the sampling area less deeply than what has been the norm in the past.

A primary object of the present invention is to provide a thermocouple which is practically impervious to moisture in the atmosphere surrounding the apparatus into which it is inserted. Another object of the present thermocouple is to be more durable and less intrusive in the sample area which it monitors than was obtained heretofore. Yet another object of the present invention is to provide a thermocouple which is readily adapted for insertion in an existing thermowell, as well as being adapted to receive an outer threaded sleeve or relatively complete cover. A further object of the present thermocouple is to be readily removable from the sample area it is intended to monitor.

Brief Description of the Drawings:

Fig. 1 is a front elevational view of a thermocouple according to the present invention equipped with a threaded metallic outer shell;

Fig. 2 is a vertical sectional view taken along line 2-2 of Fig. 1 and particularly illustrating the manner in which the present thermocouple is constructed;

Fig. 3 is a front elevational view of a thermocouple according to the present invention equipped with an elongated metal tube or thermowell; and

Fig. 4 is a vertical sectional view taken along line 4-4 of Fig. 3 and particularly illustrating the manner in which the present thermocouple is mounted in the tube or thermowell.

Detailed Description of the Preferred Embodiment:

As best indicated in Figs. 2 and 4, the present thermocouple, generally designated 10, basically comprises at least one and preferably two thermoelements 11, a unitary ceramic insulator 12 formed with at least one and preferably two relatively spaced apart thermoelement-receiving passageways 13, and a unitary ceramic sheath 14 formed with an insulator-receiving chamber 15. Preferably, the thermoelements are either iron-constantin or chromel-alumel wires, although other thermocouple alloys may be employed.

The thermoelement insulator 12 is preferably an elongated, cylindrical article fabricated from high purity calcined alumina oxide powder which is milled and blended with some plasticizers and flexing agents to provide an homogeneous material of ninety-six percent alumina oxide content. Other material compositions fall within the scope of the present invention which is not to be restricted to this one preferred embodiment. Typically, this alumina oxide material is extruded to form the insulator 12, and is then sintered at elevated temperatures to form it to its final dimensions. One of the bare thermoelement wires 11 is inserted into and through each of the passageways, and a conventional thermocouple junction 16 is provided at a

sensor end of the ceramic insulator 12 adjacent to the closed end of the insulator-receiving chamber 15 of the ceramic sheath 14.

Preferably, the ceramic sheath 14 is manufactured by those methods commonly used to fabricate spark plug insulators from high purity alumina oxide formulas. In this instance, the calcined alumina oxide powder is milled and blended with plasticizers and fluxing agents to form an homogeneous material of ninety-six percent alumina oxide content. This material is then extruded or isostatically pressed into blanks. The resulting blank is then shaped to its unfired profile and dimensioned by lathe cutting or form grinding. Alternatively, the unformed alumina oxide material may be injection molded into the desired shape. Once the ceramic sheath 14 is shaped, it is sintered under controlled firing conditions at elevated temperatures where it is reduced in size to the final dimensions, within standard commercial tolerances.

The thermoelement-bearing ceramic insulator 12 is then coated with a high temperature alumina ceramic cement and inserted into the ceramic sheath 14. This assembly is then cured under controlled temperature conditions to set the adhesive. Note that fillers, such as powdery fillers (e.g., sand, magnesium oxide) are not necessary in the assembly of the present invention. If the foregoing assembly is intended for use in an existing thermowell, then no more needs to be done to the assembly 10 other than to apply ANSI standard colored insulation to the thermoelement

wires 11 so that the connection to the instrumentation (not shown) will result in accurate temperature levels being monitored. Once the sensor assembly 10 is inserted into the thermowell, an externally threaded gland 18 (Fig. 4) may be screwed onto the cooperative internal threads of the thermowell in surrounding and overlying relation to an upper shoulder portion 19 of the ceramic sheath 14.

As indicated in Figs. 3 and 4, the present ceramic thermocouple 10 may be fitted cartridge-style into a stainless steel tube 20. This tube 20 may be somewhat permanent to the manifold or other housing into which it is installed and thus may constitute the above-referenced thermowell. The subject tube or thermowell 20 is formed with a sheath-receiving chamber 21, the sensor end of which is closed. Preferably, the tube 20 is designed to project into the manifold or other chamber no more than one-quarter of the distance between opposing walls thereof. Advantageously, the outer tube or thermowell 20 is equipped with external threads for cooperative engagement with a threaded coupling (not shown) on the manifold wall. In addition, a hexagonal or octagonal head or shoulder 23 is formed on the stainless steel tube for extracting and fastening the tube to the manifold or chamber wall.

Alternatively, as indicated in Figs. 1 and 2, the present ceramic thermocouple 10 may be fitted into a steel shell 23 which is hermetically sealed to the ceramic sheath 14 in a manner well known in the art of sealing a spark plug insulator to its surrounding metal shell. Preferably, the

shell is formed with standard SAE spark plug threads 24, a gasket 25 and a hexagonal or octagonal head 26. Preferably, the shell 23 is mounted on the ceramic thermocouple 10 so that the sensor end 16 of the thermocouple projects at least one inch into the chamber which is to be monitored. In the case of exhaust gas temperature monitoring, the sensor end 16 preferably extends less than one-half of the distance between opposing walls of the manifold in which it is mounted.

As an alternative to SAE threads 24, the shell may be provided with ISO or DIN standard spark plug threads, as well as with NPT threads. In this manner, the subject thermocouple may be replaced as easily as a spark plug and/or retrofitted into an existing threaded socket. Since the majority of prior art exhaust gas thermocouples have used one-fourth, three-eights, one-half or three-fourths inch NPT threads, it would be advantageous to employ 18 millimeter by 1.5 millimeter SAE or ISO spark plug threads. Preferably, a range of thread lengths would be provided, typically 12.7 millimeters, 18.5 millimeters and 25.4 millimeters. The 18.5 millimeter length would be virtually identical to the thread length of a one-half inch NPT pipe thread.

In addition, using TIG-welding procedures typically used in the manufacture of specialized industrial spark plugs, the manufacturer or operator may attach additional

threads to the shell 23, thereby allowing for attachment of various hazardous location protective heads (not shown) for suppressing sparks and/or corrosion.

Thus, the present invention provides a thermocouple which is readily adapted for use in a variety of applications, either in combination with a metal tube or thermowell projecting into the area whose temperature is to be monitored or in association with a threaded metal shell similar in construction to those employed with spark plugs. The present ceramic thermocouple 10 is preferably of cartridge design for ready replacement and for relatively permanent attachment to a spark plug-type threaded metal shell 23. By constructing the present thermocouple 10 from a unitary alumina oxide insulator 12 which houses the thermoelements and a surrounding unitary alumina oxide sheath 14, the present invention is able to withstand the forces at work in the chamber being monitored and in the surrounding environment which tends to cause conventional thermocouples to ground out.

What is claimed is:

1. A thermocouple assembly to be used within an apparatus to be monitored, comprising:

a unitary ceramic insulator formed with at least one thermoelement-receiving passageway;

at least one thermoelement at least partially disposed within said passageway; and

a unitary ceramic sheath formed with an insulator-receiving chamber, within said chamber said unitary ceramic insulator is tightly secured such that said sheath and said insulator are void of any powdery fillers along the entire length of said sheath.

2. The thermocouple according to Claim 1, wherein the ceramic insulator is axially elongated and is provided with a sensor end at which a terminal portion of the thermoelement is disposed.

3. The thermocouple according to Claim 2, wherein the insulator-receiving chamber of the ceramic sheath is axially elongated and is formed with a closed end adjacent to which the sensor end of the insulator is disposed and with an open end out of which the insulator and thermoelement project.

4. The thermocouple according to Claim 3, wherein a metal thermowell is formed with a closed end which

projects into the apparatus to be monitored, said ceramic sheath being adapted to be mounted in the thermowell with the closed end of the insulator-receiving chamber disposed adjacent to the closed end of the thermowell.

5. The thermocouple according to Claim 3, which includes a metal tube having a closed end and cooperative fastening means for securing said tube to a wall portion of the chamber to be monitored.

6. The thermocouple according to Claim 5, wherein the sheath is adapted to be inserted in the tube with the closed end of the insulator-receiving chamber disposed adjacent to the closed end of the tube.

7. A thermocouple assembly adapted to monitor a sample area within a manifold or other apparatus comprising:

a unitary ceramic insulator formed with at least one thermoelement-receiving passageway;

at least one thermoelement at least partially disposed within said passageway;

a unitary ceramic sheath formed with an insulator-receiving chamber, wherein said unitary ceramic insulator is tightly secured within said chamber; and

a metal thermowell relatively permanently installed in said apparatus, said thermowell formed with a

sheath-receiving bore wherein said unitary ceramic sheath may be inserted into said bore and said unitary ceramic sheath of a cartridge style in that said sheath may be removed from said thermowell and replaced with another sheath while said thermowell remains installed within said apparatus.

8. The thermocouple according to Claim 7, wherein the insulator-receiving chamber of the ceramic sheath is formed with a closed end and wherein the metal shell is mounted on the ceramic sheath in such a manner that the closed end of said sheath projects into the sample area to be monitored less than one-half of the distance between opposing walls of said sample area.

9. A method of making a thermocouple, said method comprising:

forming a unitary ceramic insulator with at least one passageway extending axially therethrough;

mounting a thermoelement in the insulator passageway;

forming a unitary ceramic sheath with an insulator-receiving chamber; and

securing the ceramic insulator within the insulator-receiving chamber of the ceramic sheath in such a way that said thermocouple is practically impervious to

moisture and is void of any powdery fillers throughout the entire length of said ceramic sheath.

10. The method according to Claim 9, which further includes forming a thermoelement junction at one end of the ceramic insulator, forming the insulator-receiving chamber of the ceramic sheath with a closed end, and securing the ceramic insulator within the ceramic sheath with the thermoelement junction end of said insulator disposed adjacent to the closed end of the insulator-receiving chamber.

11. A method of making a thermocouple assembly which is adapted to monitor a sample area within an apparatus, said method comprising:

forming an insulator with at least one passageway extending axially therethrough;

placing a thermoelement in said insulator passageway;

forming a sheath with an insulator-receiving chamber;

securing said insulator within said insulator-receiving chamber of said sheath; and

forming a metal thermowell with a sheath-receiving bore, said thermowell adapted to be relatively permanently installed within said apparatus to be monitored, said

assembly of a cartridge style such that said sheath containing said insulator and said thermoelement is readily removable and replaceable within said thermowell while said thermowell remains installed within said apparatus.

AMENDED CLAIMS
[received by the International Bureau on 08 November 1991 (08.11.91); original claims 5,7,8 and 11 amended; other claims unchanged (3 pages)]

projects into the apparatus to be monitored, said ceramic sheath being adapted to be mounted in the thermowell with the closed end of the insulator-receiving chamber disposed adjacent to the closed end of the thermowell.

5. The thermocouple according to Claim 3, which includes a metal tube installed in said apparatus, said tube having a closed end and cooperative fastening means for securing said tube to a wall portion of the apparatus to be monitored.

6. The thermocouple according to Claim 5, wherein the sheath is adapted to be inserted in the tube with the closed end of the insulator-receiving chamber disposed adjacent to the closed end of the tube.

7. A thermocouple assembly adapted to monitor a sample area within a manifold or chamber wall comprising:

a unitary ceramic insulator formed with at least one thermoelement-receiving passageway;

at least one thermoelement at least partially disposed within said passageway;

a unitary ceramic sheath formed with an insulator-receiving chamber, wherein said unitary ceramic insulator is tightly secured within said chamber; and

a metal thermowell installed in said manifold or chamber wall, said thermowell formed with a sheath-receiving

bore wherein said unitary ceramic sheath may be inserted into said bore and said unitary ceramic sheath of a cartridge style in that said sheath may be removed from said thermowell and replaced with another sheath while said thermowell remains installed within said manifold or chamber wall.

8. The thermocouple according to Claim 7, wherein the insulator-receiving chamber of the ceramic sheath is formed with a closed end and wherein the thermowell is mounted on the ceramic sheath in such a manner that the closed end of said sheath projects into the sample area to be monitored less than one-half of the distance between opposing walls of said sample area.

9. A method of making a thermocouple, said method comprising:

forming a unitary ceramic insulator with at least one passageway extending axially therethrough;

mounting a thermoelement in the insulator passageway;

forming a unitary ceramic sheath with an insulator-receiving chamber; and

securing the ceramic insulator within the insulator-receiving chamber of the ceramic sheath in such a way that said thermocouple is practically impervious to

moisture and is void of any powdery fillers throughout the entire length of said ceramic sheath.

10. The method according to Claim 9, which further includes forming a thermoelement junction at one end of the ceramic insulator, forming the insulator-receiving chamber of the ceramic sheath with a closed end, and securing the ceramic insulator within the ceramic sheath with the thermoelement junction end of said insulator disposed adjacent to the closed end of the insulator-receiving chamber.

11. A method of making a thermocouple assembly which is adapted to monitor a sample area within an apparatus, said method comprising:

forming an insulator with at least one passageway extending axially therethrough;

placing a thermoelement in said insulator passageway;

forming a sheath with an insulator-receiving chamber;

securing said insulator within said insulator-receiving chamber of said sheath; and

forming a metal thermowell with a sheath-receiving bore, said thermowell adapted to be installed within said apparatus to be monitored, said

STATEMENT UNDER ARTICLE 19

Claims 5, 7, 8 and 11 have been amended slightly in response to the notification accompanying the international search report dated October 8, 1991. The claims were amended to correct minor deficiencies present in the claims as originally filed. These amendments do not go beyond the disclosure in the international application as filed.

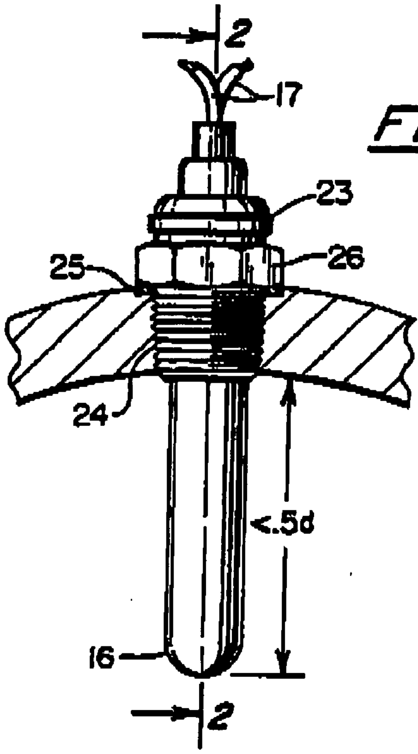

FIG. 1

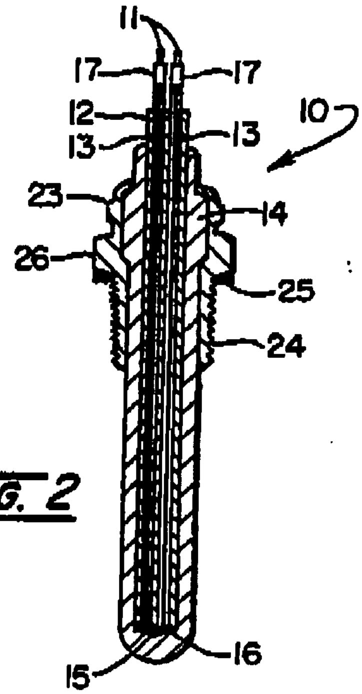

FIG. 2

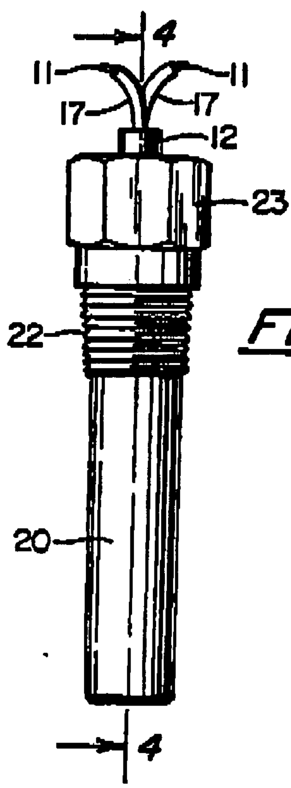

FIG. 3

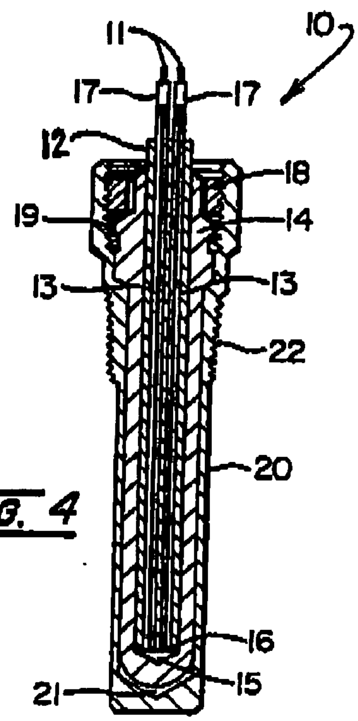

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/05432

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (5): G01K 1/10,1/12,7/02.H01L 35/02
U.S.Cl.: 136/230,232,201; 374/179

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	136/201,230,232 374/179;144

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X/Y	US, A, 3,960,604 (HEITZINGER ET AL.) 01 June 1976 See entire document	1-3,9,10
Y	US, A, 4,776,705 (NAJJAR ET AL.) 11 October 1988 See Fig. 1 description and entire document.	4,7,8,11
Y	US, A, 4,721,533 (PHILLIPPI ET AL.) 26 January 1988 See column 2, lines 36-46.	4,7,8,11
Y	US, A, 4,778,537 (THOM ET AL.) 18 October 1988 See entire document.	5,6
A	US, A, 3,929,511 (SOLOMON) 30 December 1975	
A	US, A, 4,002,924 (BUSCH) 11 January 1977	
A	US, A, 4,018,624 (RIZZOLO) 19 April 1977	
A	US, A, 3,580,078 (MACKENZIE) 25 May 1971	
A	US, A, 3,923,552 (PARRIS) 02 December 1975	
A	US, A, 3,913,058 (NISHIO ET AL.) 14 October 1975	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
25 September 1991	08 OCT 1991
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Diego F. F. Gutierrez